

AUTOMATIC GREENHOUSE WATERING SYSTEM USING  
MICROCONTROLLER

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# **CHAPTER 1**

## **INTRODUCTION**

### **1.1 Background**

A greenhouse is a structure with a glass or plastic roof and frequently glass or plastic walls; it heats up because incoming solar radiation from the sun warms plants, soil, and other things inside the building. In other word, a greenhouse is a structure usually made of glass or clear plastic that provides protection and a controlled environment for raising plants indoors.

Water is the most important element in our life. Without it, we cannot survive. As we know, most of the gardener uses manual system to water their plant in the garden and also in the greenhouse. This system is inefficient. When we water manually, the possibility to over watering is high. Some plant can drown when we supply too much water to them.

In order to overcome this problem, automatic greenhouse watering system is used. Sensors such as temperature sensor and soil moisture detector are used to control the watering system in a greenhouse.

The system also has the capability to control the water level. As we know, some parts of Malaysia sometimes faces draught problem. So, there will be a tank that will act as a reservoir tank in case of water problem. In this tank, there is a sensor to ensure the water level is always at its maximum level.

## **1.2 Objectives**

The main objective of this project is to automatically control the watering system in greenhouse using temperature sensor.

## **1.3 Scope**

This project involves the evolution of watering manually to watering automatically. The controlling of the automatic watering system is use in a greenhouse. Sensor used to control the watering system is temperature sensor. Other than that, this system should also monitor the water level. Temperature of 26°C is used as the indicator value of turning on and off the valve.

## 1.4 Problem Statement

Irrigation is the most important cultural practice and most labor intensive task in daily greenhouse operation. Knowing when and how much to water is two important aspects of irrigation. To do this automatically, sensors and methods are available to determine when plants may need water.

## 1.5 Methodology

In this project, the two main parts that are evaluated are the 68HC11 and temperature sensor. The testing includes:

- Testing the evaluation board before writing the software.
- Using a 3 pin integrated circuit (IC) temperature sensor unit (IC LM35DZ) that will convert the current temperature to an appropriate voltage level. The three pins are ground (GND), voltage source ( $V_s$ ) and output voltage ( $V_{out}$ ). The signal will be converting to digital value using the Analogue to Digital Converter (ADC). This signal will be the input for the microcontroller.



Overall steps taken to achieve the objectives are:

- i. Testing the microcontroller functionality.
- ii. Downloading program into the microcontroller to test the MAX233.
- iii. Testing program in the THRSim11.
- iv. Testing the temperature sensor.
- v. Testing the relay.
- vi. Testing the valve.

## **1.6 Thesis Outline**

Chapter 1 discuss on the background of the project, objectives, scope of the project, problem statement, methodology and also the thesis outline.

Chapter 2 focuses on literature reviews of this project based on journals and other references.

Chapter 3 mainly discuss on the system design of the project. Details on the progress of the project are explained in this chapter.

Chapter 4 presents the results of the project. The discussion focused on the result based on the experiment.

Chapter 5 concludes overall about the project. Obstacle faces and future recommendation are also discussed in this chapter.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 Introduction**

*“The development of models and strategies to control the environment of greenhouse crops started with the shoot environment, that is, with the greenhouse climate. One important reason was that influencing variables such as temperature, humidity, irradiation or CO<sub>2</sub> concentration are easier to measure and to control.”*

[Hans Peter Klaring, 2000]

From this research, we can see that there are a few factors that need to be control in a greenhouse. Those factors that need to be considered are temperature, humidity, irradiation or carbon dioxide concentration. But, in this project, factors that are going to be considered are only the temperature and humidity in a greenhouse.

## 2.2 Microcontroller

A microcontroller is a highly integrated chip which performs controlling functions. A microcontroller, or embedded controller, is similar to a microprocessor as used in a personal computer, but with a great deal of additional functionality combined onto the same monolithic semiconductor substrate. Microcontrollers, sometimes referred to as one-chip microcomputers, are used to control a wide range of electrical and mechanical appliances. Since they were first introduced, microcontrollers have evolved to the point where they can use for increasing complex applications. Some microcontrollers in use today are also programmable, expanding the number of application in which they can be used.

## 2.3 Sensors

Temperature sensor is often sensing devices embedded within some sort of insulation. The insulation may often be for electrical purposes - to isolate the sensor electrically.

*“Irrigation is the most important cultural practice and most labor intensive task in daily greenhouse operation. Knowing when and how much to water is two important aspects of irrigation. To do this automatically, sensors and methods are available to determine when plants may need water.” [Dr. Peter Ling, 2005]*

In this article, it suggested we use soil moisture detector to do irrigation. Two suggested soil moisture detector are tensiometer and dielectric sensor. Advantage of a tensiometer is that they are not affected by the temperature of the soil water solution or the osmotic potential (the amount of salts dissolved in the soil water), as the salts can move into and out of the ceramic cup freely. Therefore tensiometer readings are not affected by electroconductivity (EC) or soil temperature. But, this type of sensor will need maintenance. Water in the tensiometer cavity needs frequent refilling when tensiometers are used in dry environments where the tensiometer becomes a source of water that seeps out due to drier surrounding soil.

*“A sensor is a device placed in the system that produces an electrical signal directly related to the parameter that is to be measured. In general, there are two types of sensors, continuous and discrete.”* [Fedro S. Zazueta et al., 1993]

Continuous sensors produce a continuous electrical signal, such as a voltage, current, conductivity, capacitance, or any other measurable electrical property. For example, sensors of different kinds can be used to measure temperature, such as thermistors and thermocouples. A thermocouple will produce a voltage difference that increases as the temperature increases. Continuous sensors are used where values taken by a state variable are required and an on/off state is not sufficient, for example, to measure pressure drop across a sand filter.

Discrete sensors are basically switches, mechanical or electronic, that indicate whether an on or off condition exists. Discrete sensors are useful for indicating thresholds, such as the opening and closure of devices (vents, doors, alarms, valves, etc.). They can also be used to determine if a threshold of an important state variable has been reached. Some examples of discrete sensors are a float switch to detect if the level in a storage tank is below a minimum desirable level, a switching tensiometer to detect if soil moisture is above a desired threshold, and a thermostat to indicate if a certain temperature has been reached.

Sensors are an extremely important component of the control loop because they provide the basic data that drive an automatic control system. Understanding the operating principle of a sensor is very important. Sensors many times do not react directly to the variable being measured. For example, when a mercury thermometer is used to measure temperature, temperature is not being measured; rather, a change in volume due to a change in temperature is measured. Because there is a unique relationship between the volume and the temperature the instrument can be directly calibrated to provide temperature readings. The ideal sensor responds only to the "sensed" variable, without responding to any other change in the environment.

*“It is important to understand that sensors always have a degree of inaccuracy associated with them and they may be affected by other parameters besides the "sensed" variable. The classical example is that of soil moisture measurement using electrical conductivity probes. The electrical signal produced by this sensor is closely related to soil moisture, but is greatly affected by temperature and dissolved salts (fertilizers, etc.) in the soil. Another important factor related to the sensor is its time response. A sensor must deliver a signal that reflects the state of the system within the frame of time required by the application. Using the soil moisture measurement example, the sensor must be able to "keep up" with the changes in soil moisture that are caused by evapotranspiration. Thus, proper selection of the sensors and understanding the principle of operation is critical to the success of a control system.” [Fedro S. Zazueta et al., 1993]*

In this patent, it stated a few factors that need to be consider when we are choosing our sensors. Factors that need to be considered are such as sensors accuracy and time response. In certain project, if we will need a system that has high accuracy and fast response so sensor with high accuracy and fast response are needed. In certain cases, the factors are not essential.

*“A controlled irrigation system can include a control device for determining whether to irrigate soil and at least one irrigation structure having an actuator for*

*controlling water flow. The actuator can be communicably coupled to the control device for delivering water to irrigate a region. The controlled irrigation system further can include at least one time domain reflectometry sensor ("TDRS") located in the soil and communicably coupled to the control device for measuring soil moisture where the control device determines whether to irrigate the soil based on data from the at least one TDRS. Additionally, a method for controlling an irrigation system can include providing multiple. TDRS's having probes, distributing each TDRS at a different soil depth, measuring soil moisture content, and irrigating soil based on the measuring stepö [Dukes, Michael D. et al., 2005]*

## **2.4 Valve**

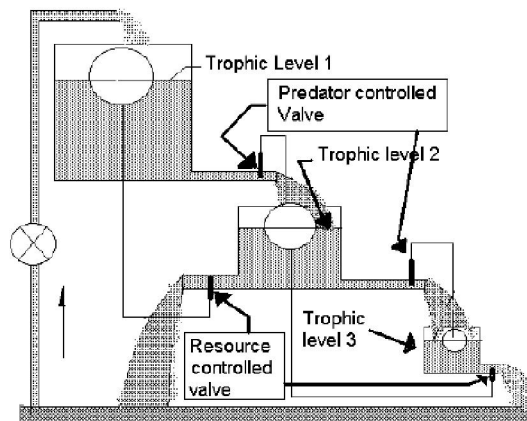
*“Solenoid valves are electromechanical valves that are controlled by stopping or running an electrical current through a solenoid, in order to change the state of the valve. A solenoid is a coil of wire that is magnetized when electricity runs through it. The solenoid valve makes use of this solenoid in order to activate a valve, thus controlling water flow, airflow and other things with electricity. Basically, there are three types of solenoid valves: the general-purpose type, low-pressure steam type and the high pressure steam type.” [Jimmy Sturo, 2006]*

In this article, it stated that there are three types of solenoid valve which are general-purpose type, low pressure steam type and the high pressure steam type. Valve is one the components that will need maintenance. The solenoid valve can get damaged after a period of time. Thus, a replacement solenoid will be needed.

## 2.5 Water Level Monitoring

*“The model consists of a series of tanks arranged one below the other. The volume of the tanks is in descending order (The highest tank being the largest). Water flows from the top tank through outlets at the bottom. Three tanks or trophic levels chosen for the model is the optimum number required to analyze the effect of top down and bottom up controls. Each tank has two outlets, outlet a and outlet b. Each outlet has the water flow through it regulated by means of valves. These valves are controlled by floats in the tanks. Valve a of each tank is controlled by the level of water in the tank above it (preceding) while valve b is controlled by the level of the water in the given tank itself. The water from the last tank and outlets a flow into a large basin from which the water is re-circulated to the 1st tank.” [Maurice S. Devaraj, 2005]*

In this journal, it discuss on the model of a flow control. This model can used to control the flow control of the water in the tank. From this model, the idea for monitoring water level is produced. This is to ensure that the plant will always get water even though drought happens.



**Figure 2.1:** Three Tank Model

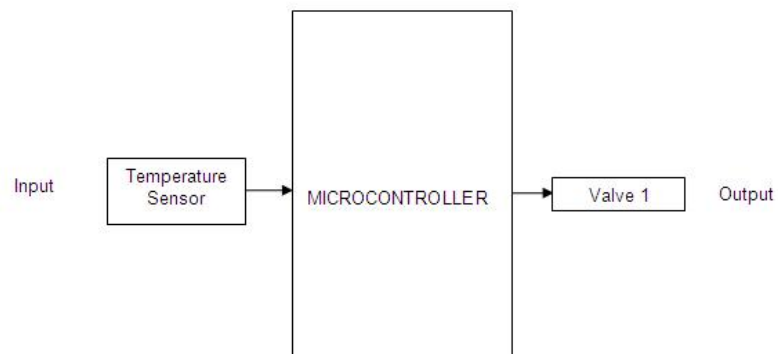


## CHAPTER 3

### SYSTEM DESIGN

#### 3.1 Overall System Design

Basically, this project consists of an input and an output. The input is the temperature sensor and the output is the irrigation valve. The block diagram is shown in Figure 3.1.

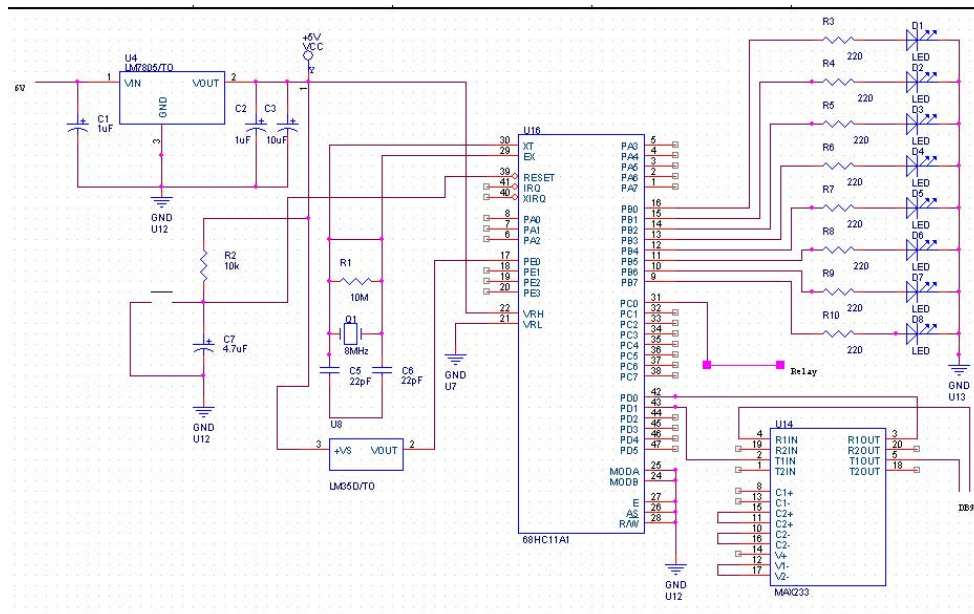


**Figure 3.1:** Block Diagram

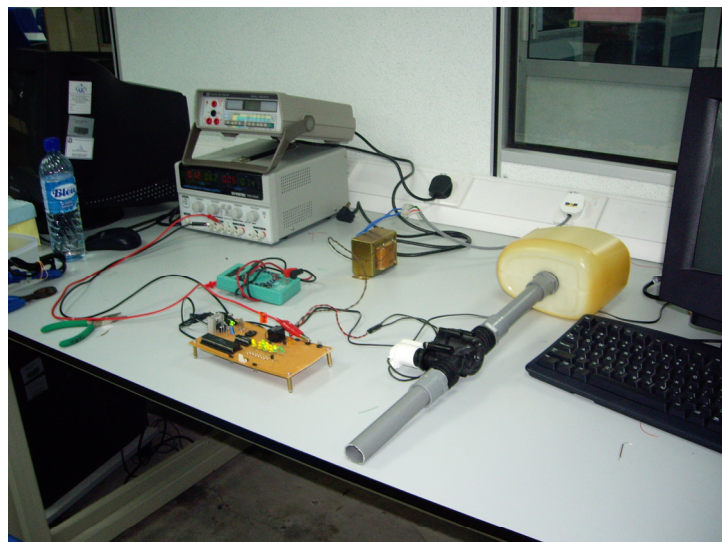
Temperature sensor gives input to the microcontroller and the output of the microcontroller will drive the valve to activate. The output of the microcontroller is driven by the temperature sensor itself. A relay is needed to drive the valve since the valve uses the on/off switching. In this project, a relay of 6V is used. The value of the relay is not important since it is only used to drive the valve. The connection of the valve and the relay is isolated in the relay itself.

For this project, temperature of 26°C is the value indicated to turn on and off the valve. If the temperature is higher than 26°C, the valve will turn on and vice versa. At first, the microcontroller will scan the environment temperature. The LED will display running light indicating that the program is running. Once the microcontroller detected that the temperature is higher than 26°C, all of the LED at Port B and the indicator light at the valve will turn on. Thus, the valve is turn on. As long as the microcontroller does not detect the temperature is higher than 26°C, all of the LED and indicator light at the valve will not turn on meaning the valve is in off state. The overall schematic design is shown in Figure 3.2.

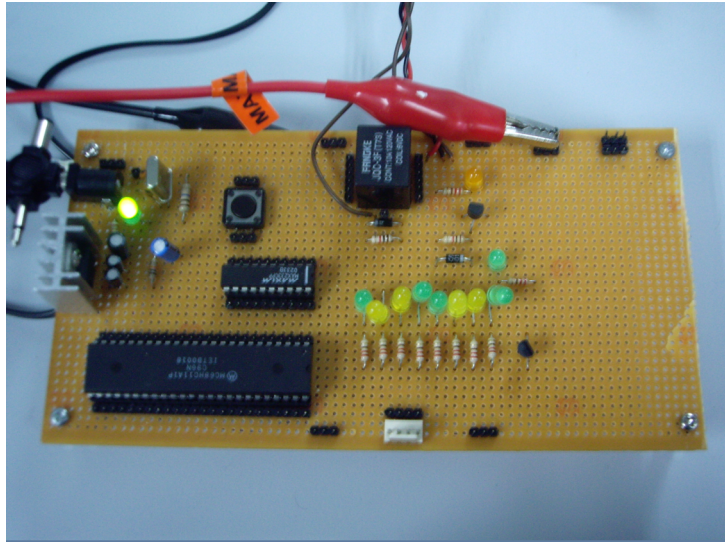
Figure 3.3 shows the overall system design of the project while Figure 3.4 shows the controller of the watering system. The lighting LED indicates there is power supply supplied to the board.



### Figure 3.2: Full Circuit Design



**Figure 3.3: Overall System Design**



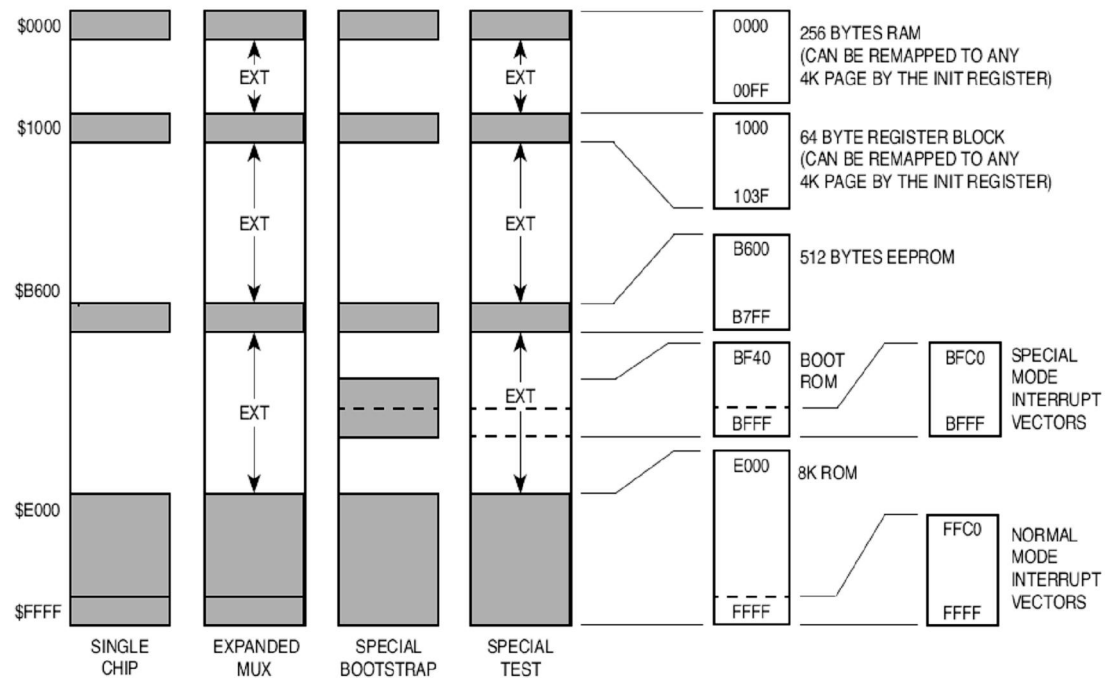
**Figure 3.4:** Controller of the Watering System

### 3.2 MC68HC11 Evaluation Board

The microcontroller that will be used in this project is MC68HC11A1 that consists of 256 RAM. Port E is used for input port. While Port B and Port C are use for output port

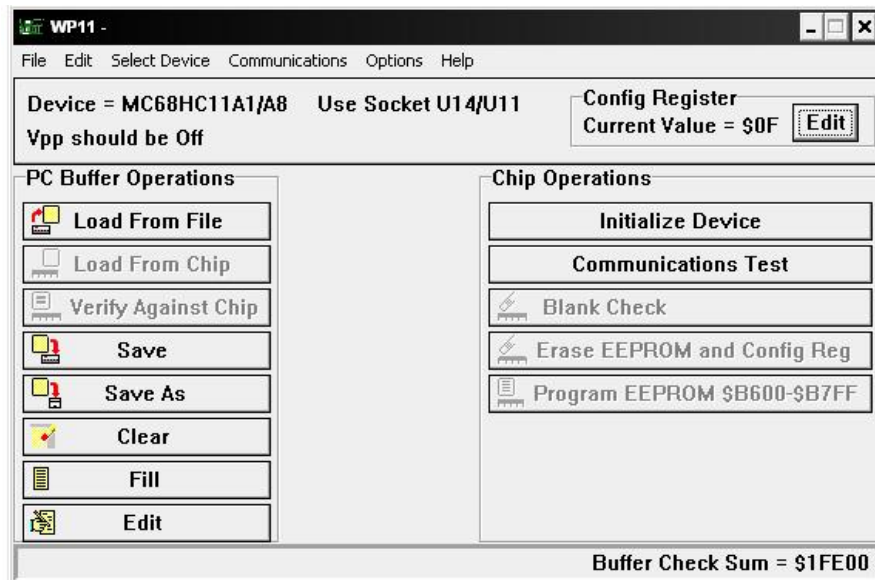
The main part that will need to be done is constructing the bootstrap mode circuit. In this stage, the clock needs to be generated. Once the circuit has been constructed, we will test the clock. By giving supply to the microcontroller, output is tapped from pin 27 of the microcontroller to an oscilloscope. From there, we will see that there is a waveform generated on the oscilloscope. This waveform is the waveform of the pulse generated by the microcontroller.

Figure 3.5 shows the memory map of 68HC11 that we should know before the software part is developed.



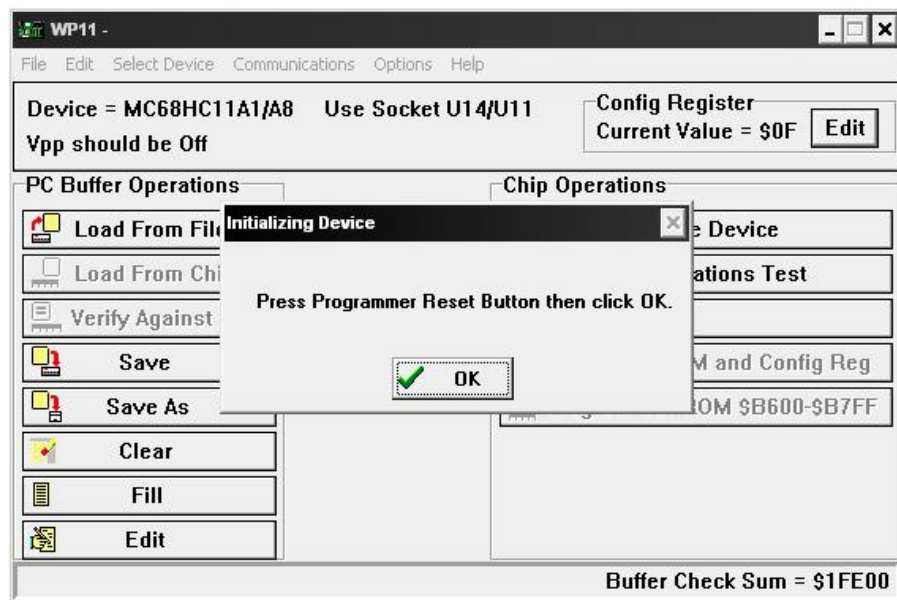
**Figure 3.5: Memory Map**

The microcontroller is programmed by using software named WP11. Figure 3.6 shows WP11 software. Before programming the microcontroller, we will need to perform communication test and initialize the board by clicking the communication test and initialize device button.



**Figure 3.6: Software WP11**

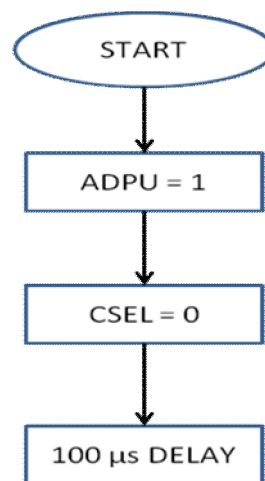
When clicking on the initialize device button, a box saying "Press Programmer Reset Button then click OK" will appear (Figure 3.7). If the device is successful to be initialized, then it may proceed to programming the microcontroller.



**Figure 3.7: Clicking the Initialize Device Button**

After initializing the device, erase the program by clicking the erase EEPROM and Config Reg button and perform blank check to ensure that there is no other program inside the microcontroller. Finally, click on the load from file button to download the program.

Figure 3.8 shows step to initialize the Analog-to-Digital Converter (ADC). Firstly, we need to set the ADPU to 1 so that the ADC is turn on. ADPU stand for analog to digital power unit. Then CSEL is set to 0 since we use the internal clock. CSEL stand for clock select. Lastly, a 100  $\mu$ s delay is required to stabilize the system.



**Figure 3.8:** Flowchart of Initializing ADC

### 3.3 THRSim11 Software

The Motorola 68HC11 microcontroller is a popular microcontroller used in many applications. Before downloading program into the microcontroller, the program needs to be assembled. With the THRSim11 program you can edit,

assemble, simulate and debug programs for the 68HC11 on your windows PC. You can also use THRSim11 to debug the program on your target EVM or EVB compatible board. The simulator simulates the CPU, ROM, RAM, and all memory mapped I/O ports. It also simulates the on board peripherals such as:

- timer (including pulse accumulator),
- analog to digital converter,
- parallel ports (including handshake),
- serial port,
- I/O pins (including analog and interrupt pins).

While debugging the graphical user interface makes it possible to view and control every register (CPU registers and I/O registers), memory location (data, program, and stack), and pin of the simulated microcontroller even when the program is running. It is possible to stop the simulation at any combination of events. For example, stop when RxD becomes low and RAM location \$003F contains \$BD or I/O register TCNT is greater than \$3456.

A number of (simulated) external components can be connected to the pins of the simulated 68HC11 while debugging. For example:

- LED's,
- switches,
- analog sliders (variable voltage potential).
- serial transmitter and receiver.

There is also a 4 x 20 LCD character display mapped in the address space of the 68HC11. THRSim11 can communicate with the Motorola EVM and EVB boards or with any other board running the BUFFALO monitor program. This



monitor program can be downloaded (for free) from the Motorola website. When your assembly program is loaded into the target board the graphical user interface makes it possible to view and control every register (CPU registers and I/O registers) and memory location (data, program, and stack) of the real microcontroller. It is possible to stop the execution at any address and inspect or change the registers and memory.

### 3.3.1 THRSim11 User's Manual for This Project

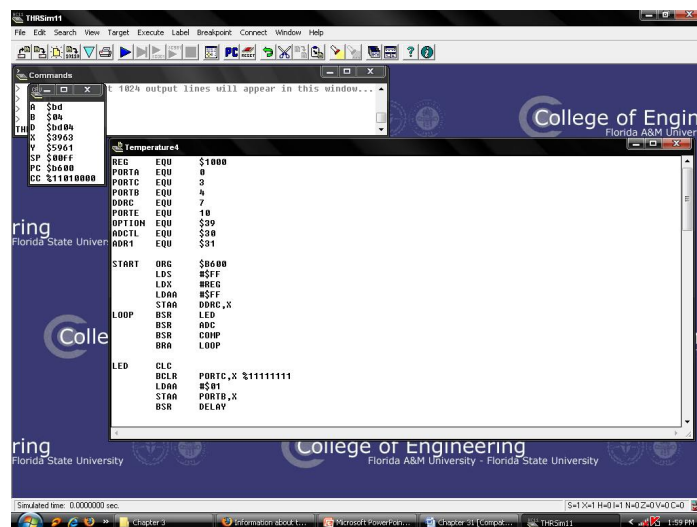
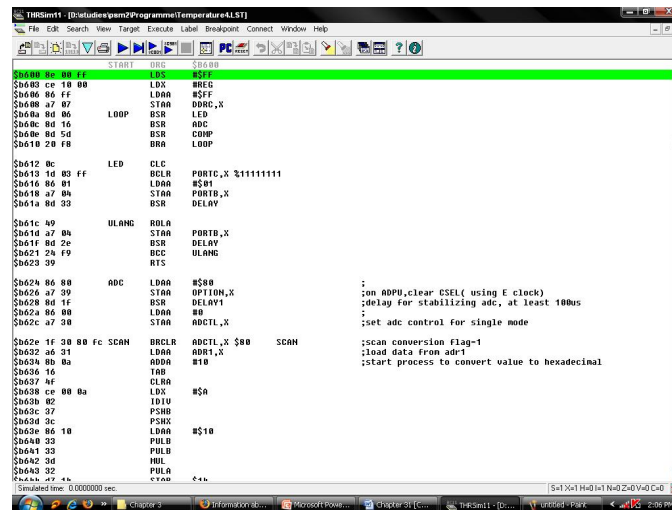


Figure 3.9: Opening a Program File

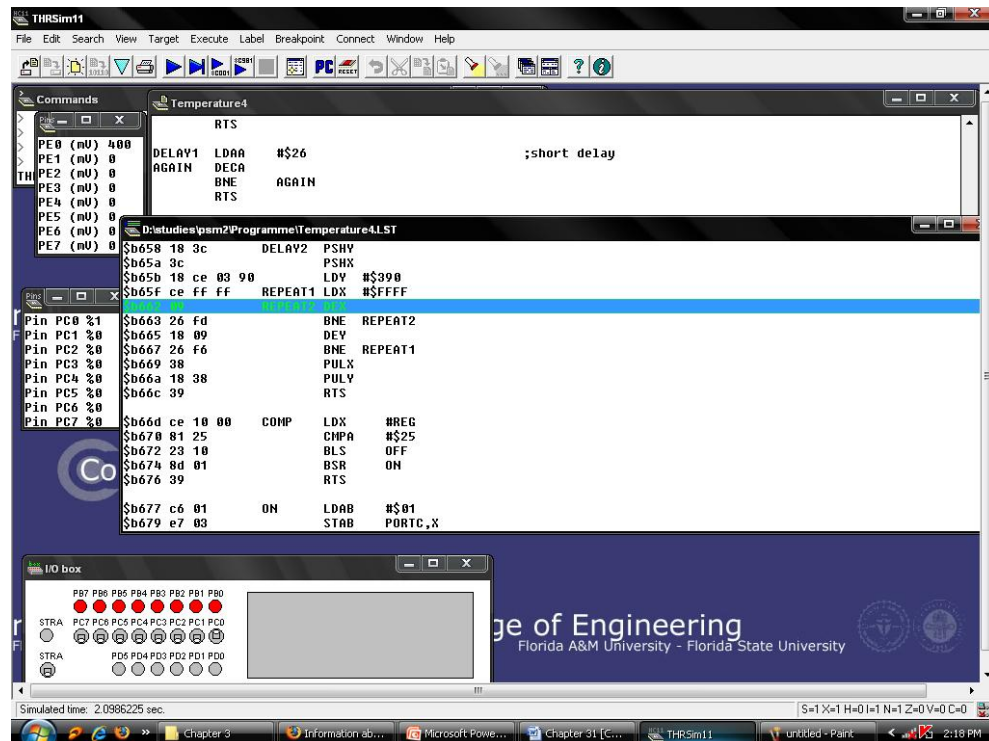


Click this button to assemble the program. All the programs need to be assembled before downloading it into the microcontroller.



**Figure 3.10: Program after Assembled**

Once it is assembled, a window like this will appear (Figure 3.10). In this window, the program is assembled into assembly language.



**Figure 3.11:** Output after Program Run



This button is used to run the program step by step. We can easily detect the error by using this button and also we can see what is done by the microcontroller step by step.



This button is used to run the program.

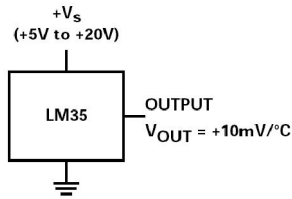


This button is used to stop the running program.

In this software, we can directly assemble and test our program whether it does function as we wanted it or not. As an example, we can see in Figure 3.11 that when an input of 400mV is given at Port E, all the LED at Port B is turn on indicating that the valve is turn on.

### 3.4 Temperature Sensor

The LM35 is an integrated circuit sensor that can be used to measure temperature with an electrical output proportional to the temperature (in °C). With an LM35, temperature can be measured more accurately than using a thermistor. The sensor circuitry is sealed and not subject to oxidation. The LM35 generates a higher output voltage than thermocouples and may not require that the output voltage be amplified.



**Figure 3.12:** Pin Configuration of LM35

For LM35, the scale factor is  $0.01\text{V}/^{\circ}\text{C}$  meaning the nominal output voltage is  $250\text{mV}$  at  $25^{\circ}\text{C}$  and  $1.000\text{V}$  at  $100^{\circ}\text{C}$ . It does not require any external calibration or trimming. The most important characteristic of the LM35 is that it draws only  $60\text{ }\mu\text{A}$  from its supply and produces a low self heating capability.

The output of temperature sensor is sensed by using a voltmeter. The output voltage is converted to temperature by a simple conversion method. The general equation used to convert from the output temperature to temperature is:

$$\text{Temperature } (^{\circ}\text{C}) = V_{\text{out}} * 100\text{ }^{\circ}\text{C/V}$$

The right connection of LM35 is important to make sure that we can obtain the result. Common mistake that student will do is connecting the  $V_s$  and ground pin in reverse meaning ground will be connected to  $V_s$  and vice versa. This is due to the way student views the ic from bottom view or upper view. As in the datasheet, the ic is view based on the bottom view (Figure 3.13). In this circuit, parameter value that commonly used is  $5\text{V}$ .



**Figure 3.13:** Connection Diagram for LM35DZ

### 3.5 Relay

In order to test the relay, it is connected to a LED. When there is input from both the 5V and 6V, the LED will turn on. If one of the inputs is not given, the LED will not turn on. Then, the LED is change to the irrigation valve (Figure 3.15). The configuration for the relay circuit is as shown in Figure 3.14 below.